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BUCLAP2

A COMPUTER PROGRAM FOR INSTABILITY ANALYSIS OF LAMINATED LONG PLATES SUBJECTED TO COMBINED INPLANE LOADS

USER'S MANUAL

by

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16. Abstract

The usage of the computer program BUCLAP2 is described in this manual. The program is intended for linear instability analysis of long, rectangular flat and curved laminated plates with arbitrary orientation of orthotropic axes in each layer. The loadings considered are combinations of inplane normal and shear loads. Arbitrary elastic boundary conditions are included for the sides of the plate.

This manual consists of instructions for use of the program. It includes input data requirements, output information, and sample problems. The program description is available in a separate document.

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1.0 SCOPE OF BUCLAP2

The computer program BUCLAP2 is intended for linear buckling analyses of long rectangular composite plates, flat or curved. Different combinations of inplane loads–axial, transverse, and shear–are considered. Provisions for arbitrary elastic constraints at the plate sides are included.

The analysis is based on linear elastic theory ignoring prebuckling stresses and displacements. The applied loads are considered to be constant throughout the plate.

Initially, the plate is bisected. The stiffness matrix for the half plate is computed and then appropriately merged to form the stiffness matrix of the whole plate. The degrees of freedom for this stiffness include those at the centerline of the plate as well as those at the plate sides. After the boundary conditions are applied, the minimum eigenvalue is extracted by setting the determinant of the stiffness matrix equal to zero. An iterative scheme, based on successive guesses of the loads, is used for this eigenvalue solution.

Although the plates are considered to be infinite in length, a special class of finite length plates can also be analyzed. In the absence of shear loads, plates with no "extensional-shear" coupling can be analyzed as finite length plates with simply supported ends. For these plate problems, the critical loads are calculated for each specified axial half-wave number. To find the lowest critical load of the plate, the analyst should specify a range of axial half-wave numbers.

For all other plates that are considered, critical loads corresponding to specified half-wave lengths are computed. A search using different half-wave lengths must be made to find the minimum plate buckling load.

2.0 BASIC INFORMATION

This section deals with the basic information required by BUCLAP2 users.

2.1 PLATE PROPERTIES

Both flat and curved anisotropic plates are included in BUCLAP2. The plate can be laminated where each layer is orthotropic with respect to its local lamina axes.

For a general laminated plate, care must be exercised in selecting the correct sign for the angle between the local lamina axes and the overall plate axes and also in the ordering of the laminas for curved plates. Figure 1 shows the positive sign convention for the angle, ϕ_k, between the lamina and plate axes and illustrates the ordering of the laminas as used in BUCLAP2. The first lamina is on the convex (outer) surface and the last lamina on the concave (inner) surface of the curved plate.

For other types of anisotropic plates the A_{ij}, B_{ij}, and D_{ij} (i,j = 1, 2, 6) matrices of equations (A.6) and (A.7) of reference 1 are specified.

As shown in figure 1, the radius of curvature is measured from the center of curvature to the midthickness of the plate. Only positive values of the radii should be specified.

2.2 BOUNDARY CONDITIONS

On each side of the plate, constraints can be specified on the displacement and rotation components by using input parameters. Each degree of freedom on the plate sides can be completely restrained, sprung, or freed. Three special boundary conditions are also included for the user's convenience. They are:

- Simply supported
- Clamped
- Free

2.3 LOADINGS

Axial, $\bar{N}_x$, transverse, $\bar{N}_y$, and shear, $\bar{N}_{xy}$ inplane loads are included in the analysis as uniform, applied loads. The positive sign convention for these loads is shown in figure 2. To cover some of

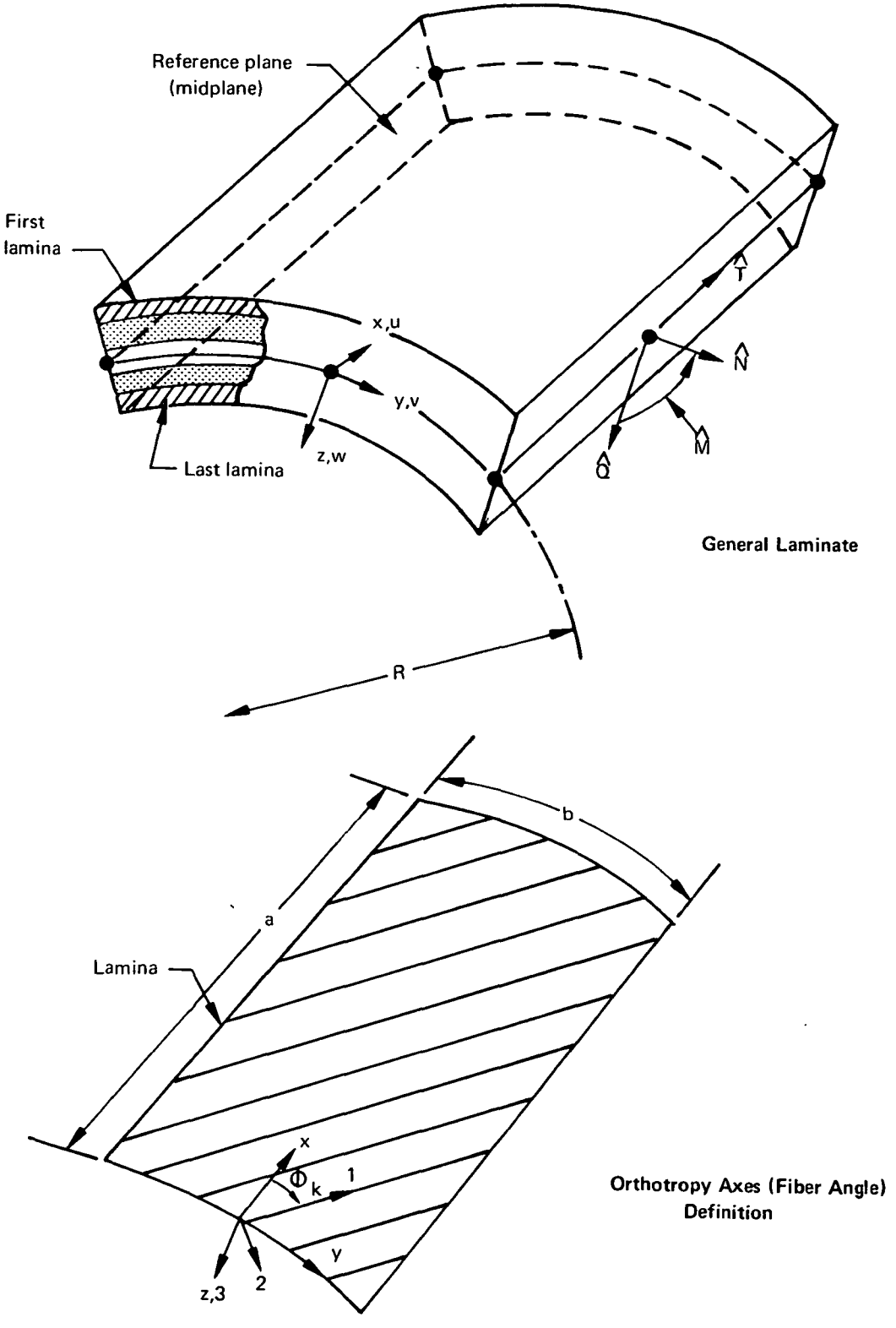


FIGURE 1.—LAMINATE GEOMETRY AND SIGN CONVENTIONS

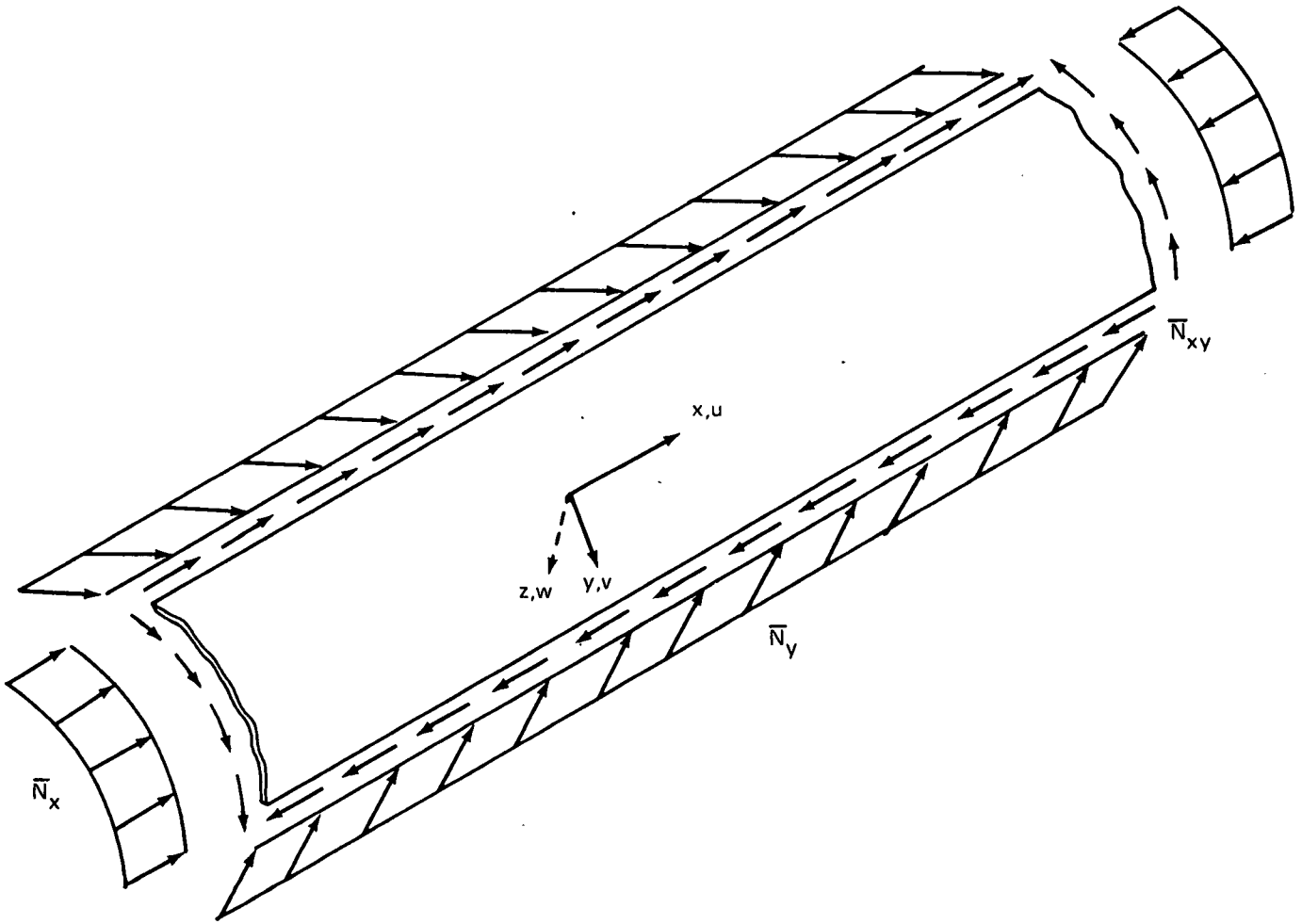


FIGURE 2.—SIGN CONVENTION FOR APPLIED LOADS (POSITIVE DIRECTIONS ARE SHOWN)

the many different combinations of these loads, seven load options are offered in BUCLAP2. These options are shown in table 1.

TABLE 1.–LOAD OPTIONS

Option	$\bar{N}_x$	$\bar{N}_y$	$\bar{N}_{xy}$	$\bar{N}_x/\bar{N}_y$	$\bar{N}_x/\bar{N}_{xy}$	$\bar{N}_y/\bar{N}_{xy}$
1	V	1	2	–	–	–
2	1	V	2	–	–	–
3	1	2	V	–	–	–
4	1	–	V	–	–	2
5	–	1	V	–	2	–
6	–	V	1	2	–	–
7	V	–	–	1	2	–

The V indicates that the load is used as the unknown in the analysis and the numbers indicate the ordering of the input values (constants). For example, in option 4, $\bar{N}_{xy}$ is the unknown used in the analysis, $\bar{N}_x$ is the first input value, and the load ratio $\bar{N}_y/\bar{N}_{xy}$ is the second input value. This particular option would be used to solve for the critical $\bar{N}_{xy}$ load where $\bar{N}_x$ and the ratio between $\bar{N}_y$ and $\bar{N}_{xy}$ remain constant.

2.4 HALF-WAVE LENGTHS

The analysis used in BUCLAP2 is based on calculating a buckling load for each half-wave length, λ. To calculate the minimum of the buckling loads of a long plate, many different half-wave lengths have to be investigated. Since it is not practical to cover the total range of half-wave lengths for a long plate, a limit should be imposed on the maximum λ and a search made within that range.

Figures 3, 4, and 5 are some examples of how the buckling load varies with respect to λ. As these figures indicate, it is possible to have more than one minimum. Therefore, it is recommended that a search be first made to define the general shape of the load vs λ curve. The areas of local minimums can then be located. To actually find the local minimums, a λ search option is available for the user. This option for finding a local minimum uses a curve-fitting scheme starting with three user-specified λ values. It is recommended that the three λ values be specified such that they are in

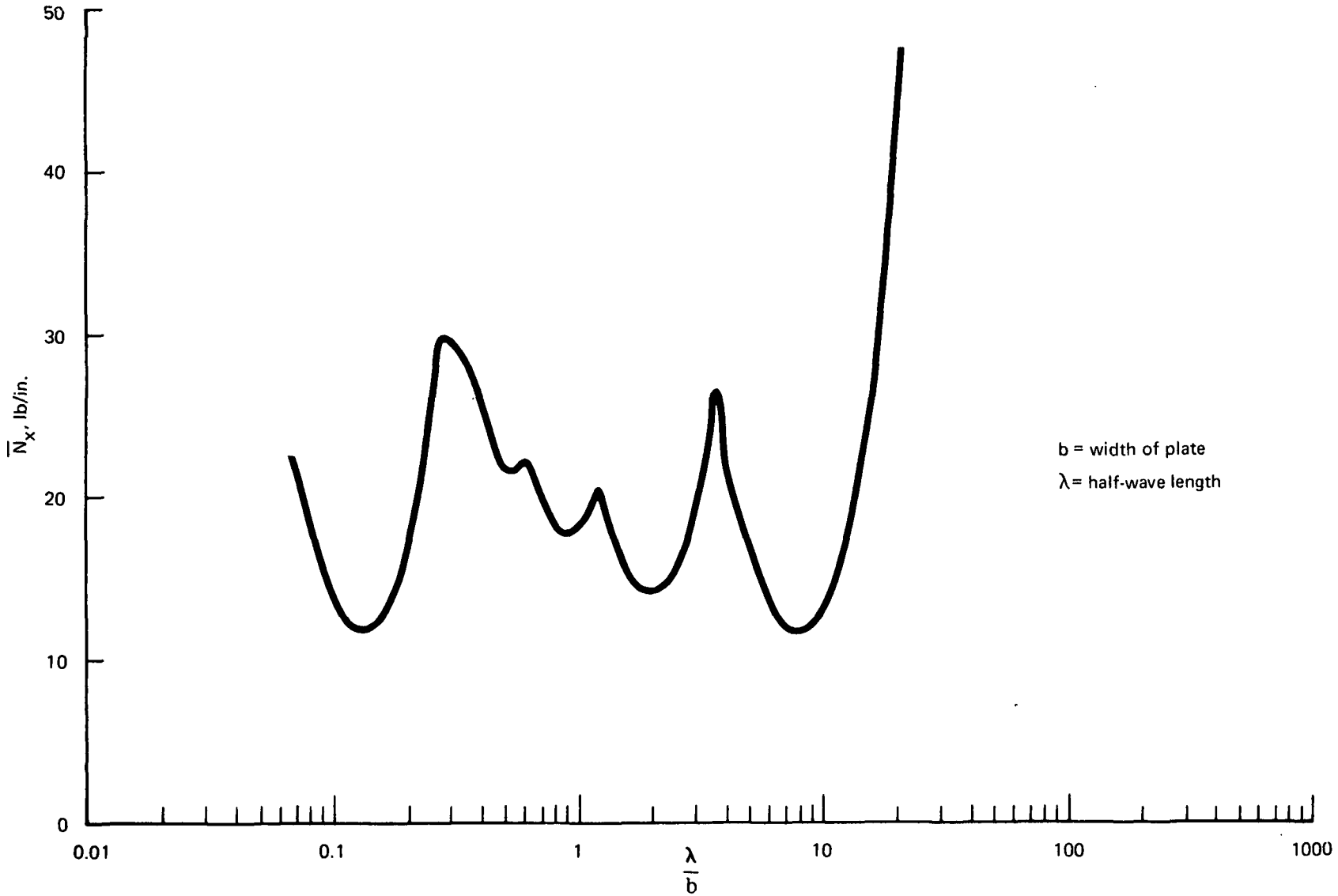


FIGURE 3.–$\overline{N}_x$ CRITICAL FOR A CURVED PLATE

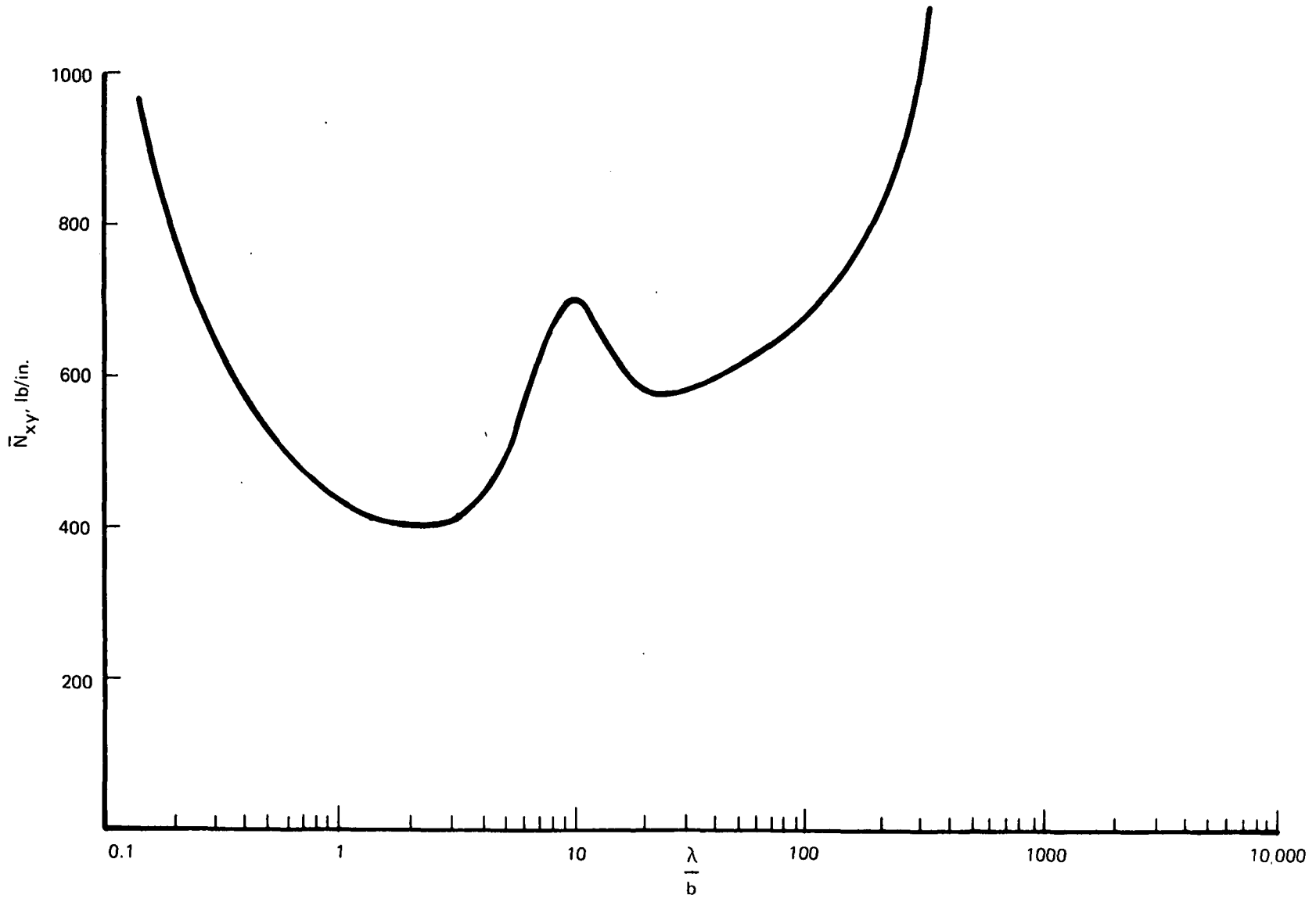


FIGURE 4.– $\bar{N}_{xy}$ CRITICAL FOR A CURVED PLATE

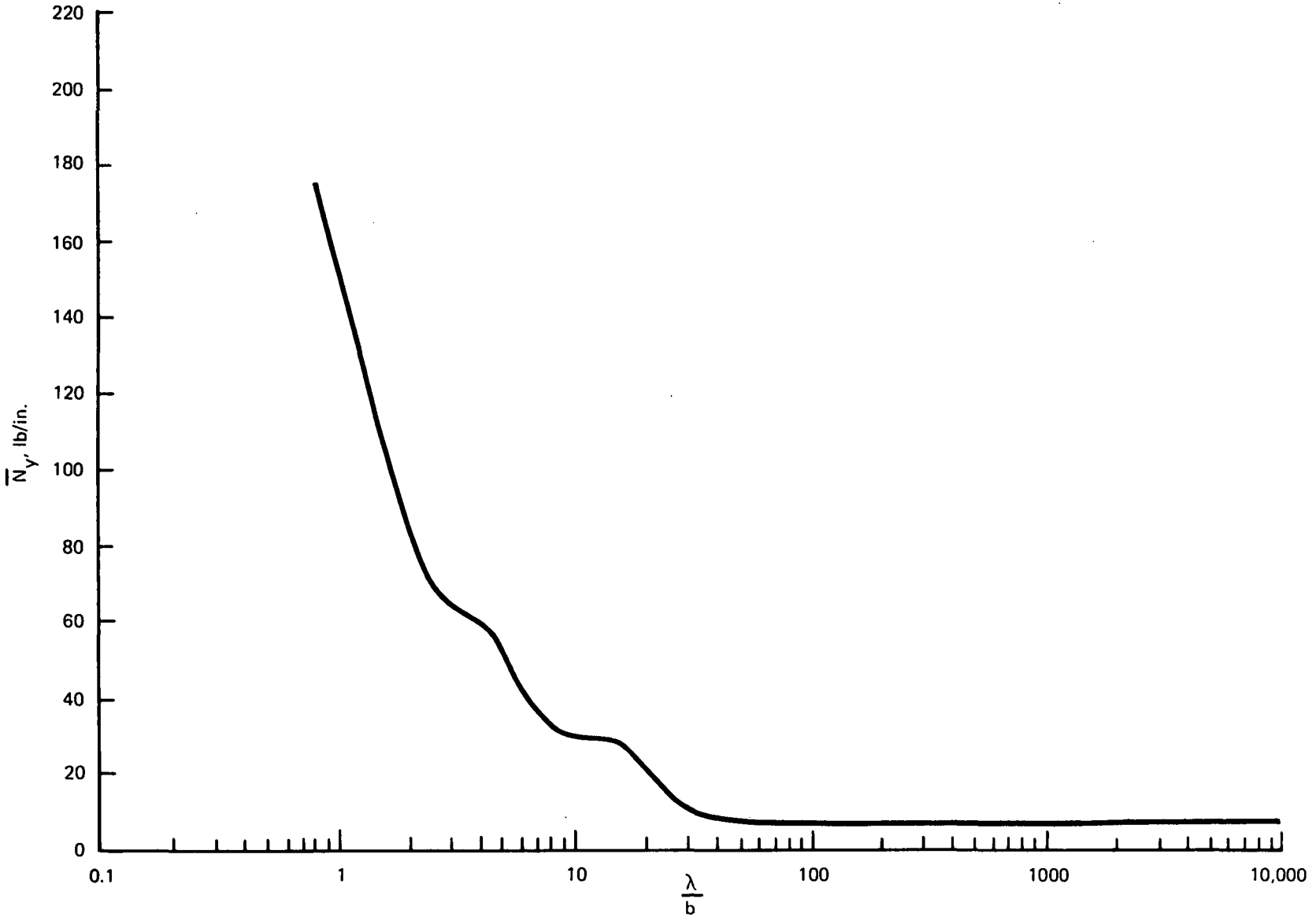


FIGURE 5.—$\overline{N}_y$ CRITICAL FOR A CURVED PLATE

ascending order and that the buckling load for the second input λ value is lower than the buckling loads for the other two λ values.

2.5 UPPER- AND LOWER-BOUND LOADS

For each half-wave length, the upper-bound load is required for the algorithm used in BUCLAP2 for extracting the minimum eigenvalue. This load is defined as the buckling load for the half plate with its sides completely restrained.

The upper- and lower-bound loads can be specified as inputs to BUCLAP2. If the bounds are not specified, an approximate upper-bound load based on the Galerkin method will be computed and the lower-bound load will be set to zero. The minimum eigenvalue should lie between these bounds.

3.0 PROGRAM COMPUTER DETAILS

The details in this manual are concerned with user information. A detailed program description is to be found in reference 2.

3.1 MACHINE REQUIREMENTS

The BUCLAP2 program is written for the CDC 6600 series computers. It requires the use of a card reader and line printer.

3.2 OPERATING SYSTEM

The program runs under the SCOPE 3.1 or KRONOS 2.0 operating systems. All system subroutines used are assumed to be standard CDC release. With the exception of three special-purpose subroutines—PAC, UNPAC, and VIPDR in COMPASS—all source routines are coded in CDC FORTRAN IV. The overlay loading feature is used.

Four NASA Langley Research Center routines are used: CXINV, DAYTIM, EECM, and SIMEQ.

CXINV *Computer Programming Manual,* Volume I, Section F1.3, 6-15-72 (NASA, LRC). CXINV solves the complex matrix equation AX = B.

DAYTIM This subroutine provides the current date and time of day.

EECM *Computer Programming Manual,* Volume I, Section F2.7, 6-15-72 (NASA, LRC) EECM computes eigenvalues for a complex matrix.

SIMEQ *Computer Programming Manual,* Volume I, Section F4.1, 8-1-68 (NASA, LRC). SIMEQ solves a set of linear equations.

3.3 STORAGE ALLOCATION

The program will LOAD and EXECUTE with a field length of 34000_8. It will EXECUTE with a field length of 27000_8.

3.4 TIMING AND OUTPUT ESTIMATES

Time consumption for one data set varies. It depends directly on the number of wave values that are investigated. The approximate time per wave value is 1.5-2 sec of CPU time.

The program will generate 7+n pages of output for a problem case, where n is the number of wave values investigated.

3.5 CONTROL CARD OPERATIONS

Discussion of specific control cards has been avoided; the required sequence of operations is specified. All file names with the exception of BUCLAP2 are arbitrary. All overlays have the name BUCLAP2; thus, a file BUCLAP2 is generated at load time.

There are three modes of execution, depending on the status of the program to be used.

The sequence for each possible mode is as follows:

(a) Source
   1. Obtain a source file, PROG, from permanent storage (cards, TAPE, permanent disk file, etc.)
   2. Compile source file placing relocatable binary on BPRG.
   3. Load BPRG.
   4. Execute BUCLAP 2.

(b) Relocatable binary
   1. Obtain a relocatable binary file, BPRG, from permanent storage.
   2. Load BPRG.
   3. Execute BUCLAP2.

(c) Absolute binary
   1. Obtain an absolute binary file, BUCLAP2, from permanent storage.
   2. Execute BUCLAP2.

4.0 PROGRAMMED DIAGNOSTIC MESSAGES

There are two types of messages. The first type is titled NOTE or WARNING and is not fatal. The second type is titled ERROR. After an error message is printed, nothing further is done on a data set except the processing of any input data remaining for that data set. Nearly all messages include the name of the originating subroutine, and some include a statement number which is near the source of the message.

The following routines print diagnostic messages:

DATIN, FLTDEF, PRERD, RDTBLE, TBPOINT — Input data processing routines

AROOT
DBLERT
GALUP
LOADCN
SOLVEC
STRAIN
WAVFND

Diagnostic messages are listed by subroutine and message number. An asterisk is placed on NOTES and WARNINGS.

DATIN

1* The HH card has been defaulted

2 HH card missing

3* Field II of card HH is illegal; default is set

4 Field II of card HH is illegal

5 Number of material tables input exceeds maximum of 40

6 Plate type II is illegal

7 Material property option II is illegal

8 Material properties input format option II is illegal

9 Number of layers exceeds limit of 25

10* Initial wave value larger than final value; numbers being reversed for processing

11* Wave value delta is negative; value being set positive for processing

12* Only the first 30 values of the wave list specified will be used

13 Preset boundary condition HHHH illegal–not CL, FR, SS, or blank

14 Load case option illegal–not 1 to 7

15 The critical wave search option can only be used with wave length input option

16 Errors on P1 card (possibly others)

17 Errors found on various cards

18 Radius is less than zero

19* Length has no meaning; half-wave lengths are input

PLTDEF

30 Not enough P2 cards were supplied for the number of layers specified

31 Invalid table number on P3 (or LM) card

32 Invalid table length on an MT card–only 4 entries permitted

33* The E22 value input for layer II was zero; it has been set to E11 value

34 The E11 value input for layer II is zero

35 Both A and D matrices must be specified when matrices are being supplied

PRERD

40* This card is not a valid type; the card is HHH . . . . HHH

41 Data set is in error; it will be bypassed; a required card is missing or extra cards were supplied

42* An END card was missing in the following data set

RDTBLE

50 End-of-file encountered reading HH table card(s)

51 Illegal data encountered reading HH card

52 Too many items on HH card

53 No values located on HH card

54 A NON HH card was read before the delimiter (/) was located

TBPOINT

60 Illegal code HH in P3 (or LM) card

61 Either a P3 (or LM) card list begins with two commas or a list value is zero

62 The number of items in section II of the P3 (or LM) card does not equal the number of layers; the number of items is II, and the number of layers is II

AROOT

70 ZARK2 failed to converge in II iterations

71 An error appeared in the alpha-eigenvalues; a complex root that is not one of a conjugate pair (The roots found are output)

DBLERT

75* Double root detected

GALUP

80 Inversion of B matrix for B matrix substitution failed

81 Eigenvalue could not be determined in the upper-bound calculation

82 No upper bound could be calculated because of matrix reduction error

83* Upper-bound calculation stopped at N = II because of matrix reduction error

LOADCN

90 Double root detected again after perturbation of trial load

91 Zero occurred on diagonal

92 Number of allowed trial load iterations, which is II, was exceeded

SOLVEC

95 An apparent singularity occurred in solving the set of complex equations for the stiffness matrix—X_d and X_f matrices will be output

STRAIN

101 Inversion of matrix failed in determining ASTAR

102 Error occurred in SIMEQ in solving for strains

WAVFND

105 Change in slopes is zero; probable cause is an input upper bound that is set too low

5.0 RESTRICTIONS

Restrictions are presented in three classifications: analysis oriented, programming oriented, and numerically oriented.

5.1 ANALYSIS-ORIENTED RESTRICTIONS

a. Linear thin shell buckling theory is used.

b. Prebuckling deformations are ignored.

c. Only inplane applied loads are considered.

d. The included angle of the curved plate is limited to 180°.

5.2 PROGRAMMING-ORIENTED RESTRICTIONS

a. The maximum number of layers is 25.

b. The maximum number of wave values that can be input in one data set is 30.

c. Two roots of the determinant expression det (DT) = 0 are considered double if they differ by less than 0.005% in both real and imaginary parts.

d. The imaginary part of the complex roots of the determinant expression det (DT) = 0 is exactly set to zero when it is less than 10^{-5} times real part of the number. Similarly the real part is exactly set to zero when it is less than 10^{-5} times the imaginary part of the number.

e. The maximum number of material tables is 40.

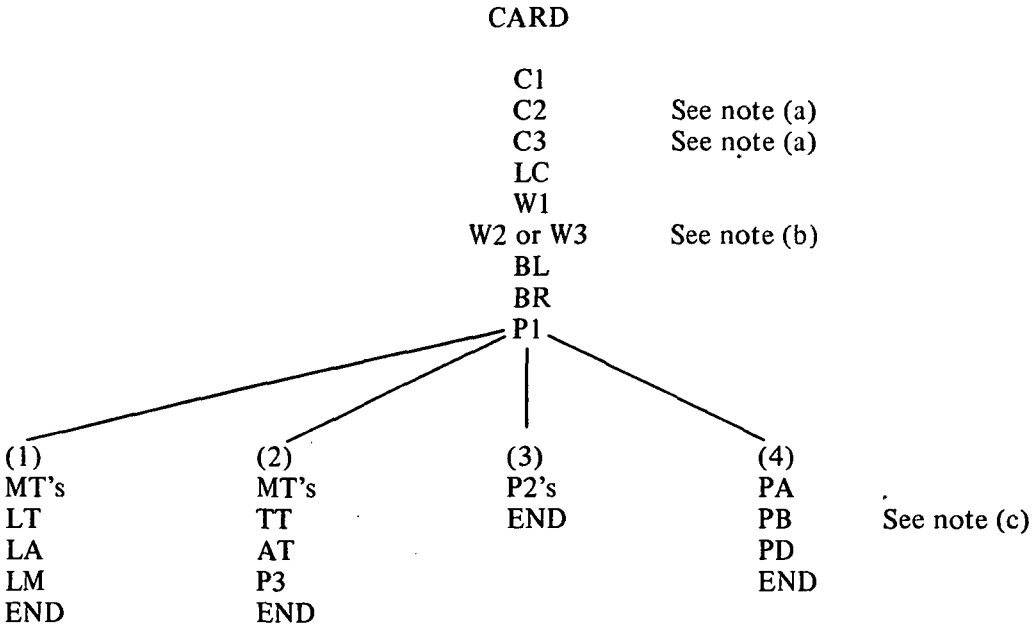
5.3 NUMERICALLY-ORIENTED RESTRICTIONS

For very large half-wave length values, the buckling results may become unreliable because of numerical inaccuracy. Suspiciously low buckling loads, sometimes observed at these half-wave lengths, seem to indicate such a phenomenon. The half-wave length at which this occurs varies from case to case.

6.0 INPUT

The data input to this program consist only of cards. No data tapes are required. The next section shows the preferred order for data card input. It is followed by a minimanual that summarizes the cards and then a detailed explanation.

6.1 DATA STACKING



Note (a) The C2 and C3 cards may be omitted, if their default values are acceptable.

Note (b) Either the W2 or the W3 card may be required depending on the option used on the W1 card.

Note (c) The PB card is not needed, if the B matrix is zero.

The recommended order of stacking is indicated above. The data cards of a data set can occur in a different order. It is essential, however, that the cards of any table be in order, that P2 cards be in order, and that the END card be at the end of the data set. It is also required that *all* cards have the card identification in columns 1-2. A number of data sets can be stacked together. If an input error is encountered in one data set, the following data sets are not affected. They will be processed.

There are four possible schemes for the cards included in a data set. The first two schemes input the structural properties on MT cards, and they provide separate cards for angles and thicknesses. The first scheme orders angles and thicknesses by layer on LA and LT cards, respectively. An LM card lists the MT table numbers ordered by layer.

In the second scheme, AT and TT cards provide angles and thicknesses. The P3 card has three sets of pointers. They point to thicknesses on TT cards, MT table numbers, and angles on AT cards.

In the third scheme, thicknesses, fiber angles, and structural properties are input on a separate P2 card for each lamina.

The fourth scheme is used when A, B, and D matrices are input rather than structural information on each layer.

6.2 BUCLAP2 MINIMANUAL

Card[a]	Data	Columns	Format
C1	Title	3-80	7A10, A8
C2[b]	Print switches–(4) α roots, (5) R matrix, (6) X_D-X_C-stiffness, (7) modified merged stiffness, (8) bounds, (9) Q's	21-50	6I5
C3[b]	Program control–(1) upper bound only, (2) data only, (3) maximum iterations	6-20	3I5
LC	LC option, first load, second load, lower bound, upper bound	6-50	I5, 4F10.0
W1	M or λ, option, initial value, final value, delta	6-50	2I5, 3I10 or 2I5, 3F10.0
W2[c]	Half-wave numbers	6-80	15I5
W3[c]	Half-wave lengths	11-80	Free
BL	Left boundary–type, input	9-70	A2, 4I5, 4F10.0

BR	Right boundary--type, input	9-70	A2, 4I5, 4F10.0
PI	Plate type, layers, length, width, radius	5-50	I1, 3X, I2, 10X, 3F10.0
$LT^{(1)}$	Thicknesses by layer	11-80	Free
$LA^{(1)}$	Angles by layer	11-80	Free
$LM^{(1)}$	MT pointers	3-80	Free (integer)
$MT^{(1,2)}$	E_{11}, E_{22}, ν_{12}, G_{12}	11-80	Free
$TT^{(2)}$	Thicknesses	11-80	Free
$AT^{(2)}$	Angles	11-80	Free
$P3^{(2)}$	Thickness/MT/angle pointers	3-80	Free (integer)
$P2^{(3)}$	t, E_{11}, E_{22}, ν_{12}, G_{12}, ϕ_k	11-70	6F10.0
$PA^{(4)}$	A matrix	11-70	6F10.0
$PB^{(4)}$	B matrix	11-70	6F10.0
$PD^{(4)}$	D matrix	11-70	6F10.0
END			

---

[a]The first two columns (or three) on all cards are the card name

[b]Optional

[c]Use depends on W1 card

[1,2,3,4]Cards used only for scheme indicated by the number

6.3 INPUT DATA FORMAT

All the cards have a card identification in columns 1-2. Fields of 5 or less are right-adjusted integers. Fields of 10 are floating point numbers with format F10.0.

Cards of a fixed-field type are the following:

C2, C3, LC, W1, W2, BL, BR, PA, PB, PD

Cards whose field is essentially free are the following:

W3, MT, LT, LA, LM, TT, AT, and P3

For P3 or LM cards, the "free" field occurs in columns 3-80; for all others it occurs in columns 11-80. Blanks within the "free" field area are ignored.

The lists on any of these "free" field cards may extend onto additional cards. The list is not complete until the right parenthesis is reached for the P3 or LM cards, or the slash in the case of the other cards. For a list on multiple cards, all cards end in a number or a comma. For those ending in a number, the end of the card serves as an implied comma; that is, it separates the numbers as does the comma. A comma followed by blanks before the end of the card will not cause a number to be inserted. On all free-field cards, if a number is omitted between commas, the last value given is used. Thus, consecutive commas serve to duplicate a value.

CARD C1 (8A10) Title Card

Columns

1-2	"C1"
3-80	Title of run. This title is placed on the top of each output page for identification.

This card is to be used in all data cases.

CARD C2 (A2, 3X, 15I5) Intermediate Print Control (IPC) Array

The intent of the options on this card is to provide controls for printing diagnostic output for checking purposes. Output is printed when a "1" is input, suppressed when a zero or blank is input.

Columns

1-2 "C2"

6-10 Not in use

11-15 Not in use

16-20 Not in use

21-25 IPC(4) = 0 (or blank) No print

= 1 Print intermediate results (4)

This option prints out the α roots of the determinant expression det (R) = 0 (buckling equations) during the buckling calculation. It also outputs the number of roots and the loads $\overline{N}_x$, $\overline{N}_y$, and $\overline{N}_{xy}$.

26-30 IPC(5) = 0 (or blank) No print

= 1 Print intermediate results (5)

This option prints out the R matrix and the α root used to calculate it.

31-35 IPC(6) = 0 (or blank) No print

= 1 Print out intermediate results (6)

This option prints out the X_D, X_F, and elemental stiffness matrix.

36-40 IPC(7) = 0 (or blank) No print

= 1 Print out intermediate results (7)

This option prints out the modified merged stiffness matrix and titles it GMTRIX.

Columns

41-45	IPC(8) = 0 (or blank)	No print
	= 1	Print out intermediate results (8)

This option prints out the upper and lower bounds being used in the critical load iteration and the tolerance being used for convergence.

46-50	IPC(9) = 0 (or blank)	No print
	= 1	Print out intermediate results (9)

This option prints out the $\overline{Q}$ values determined for each layer.

This card may be used in all data cases. It may be omitted; then no diagnostic output will be made.

CARD C3 (A2, 3X, I5I5) Program Control (JPC) Array

This card provides options on program execution.

Columns		
1-2	"C3"	
6-10	JPC(1) = 0 (or blank)	Standard execution
	= 1	Calculates the upper bound only (plate buckling omitted)
11-15	JPC(2) = 0 (or blank)	Standard execution
	= 1	Only input data cards are processed (upper bound and plate buckling omitted)
16-20	JPC(3) = 0 (or blank)	Maximum number of load iterations allowed in buckling calculation is 100.
	= n	Maximum number of load iterations allowed in buckling calculation is n. If n is < 0 or > 100, n is reset to 100.

This card may be used in all data cases. It may be omitted. In this case, the default values of zero are used for the JPC array; this results in a standard program execution.

CARD LC (A2, 7X, I1, 4F10.0) Load Case Definition

Columns

1-2	"LC"
10	Load Case Option (See table 1 on page 5). This must be a number 1-7.
11-20	First Load Value (See table 1 on page 5). Defaulted to 0.0, if it is left blank.
21-30	Second Load Value (See table 1 on page 5). Defaulted to 0.0, if it is left blank.
31-40	Lower-Bound Load for search interval. Defaulted to 0.0, if it is left blank.
41-50	Upper-Bound Load Value for the search interval. Upper bound is *calculated,* if this is left blank (or set to 0.0).

This card is to be used in all data cases.

CARD W1 Wave Value Definition

The wave value definition (W1) card is sufficient for full definition of the wave values to be used, when it has wave input option 1 or 2 specified on it. However, either a W2 or W3 card is required for a wave value list for options 3, 4, and 5. If the wave values are defined to be half-wave numbers, one or two W2 cards are used for the input list. If the wave values are defined to be half-wave lengths, W3 cards are used for the input list.

Columns		
1-2	"W1"	
10	Wave value definition	
	= 1	Half-wave numbers (m)
	= 2	Half-wave lengths (λ)
15	Wave input option	
	=1	Wave input list is to be built by using data in columns 21-50 of this card. This list is to be used until a minimum load is found.
	= 2	Same as option 1 except that all values in the wave input list are used for critical load determinations.
	= 3	Wave value input list is provided by W2 or W3 cards. This list is used until a minimum load is found.
	= 4	Same as option 3 except that all values in the wave input list are used for critical load determinations.
	= 5	Critical wave search option. Requires that the wave value be half-wave lengths and that a W3 card contain a list of three half-wave lengths in increasing order. The critical wave search option seeks a local critical load starting with these three values. If the midwave value in the list has a lower critical load than the end wave values, the critical load minimum

Columns		
		found will be at some wave value within the bounds of the wave value list.
26-30 (21-30)	Initial wave value.	
36-40 (31-40)	Final wave value.	
46-50 (41-50)	Delta wave value.	

For options 1 and 2, data are required in columns 21-50. These columns are left blank for options 3, 4, and 5. The data in these columns are used to build a wave value list. The list starts at the initial wave value and is incremented by the delta wave value until the final value is exceeded. Integer values are input for half-wave numbers, and floating-point values for half-wave lengths (floating-point field is shown above in parentheses).

The wave value list has a maximum of 30 values. In the case of the critical wave search option, a maximum of 40 values will be tried.

This card is to be used in all data cases.

CARD W2 (A5, 1515) Half-Wave Number List

This list is limited to 30 values maximum. A second card of the same format is required when there are more than 15 values.

Columns	
1-2	"W2"
6-10	First half-wave number
11-15	Second half-wave number
—	
—	
76-80	Fifteenth half-wave number

This card is to be used if the W1 card specifies half-wave numbers in the wave value definition and lists wave input options 3 or 4.

CARD W3 Half-Wave Length List

This list is limited to 30 values. If more than one card is needed, additional cards of the same format may be used. A maximum of 10 W3 cards is allowed.

The values in the list are delimited by commas and physical end of card. The table is terminated by the character slash (/).

Columns	
1-2	W3
11-80	. . ., . . ., value, . . . / where value may be nnnn, n.nnn, or n.nnnE±nn. The number of significant digits is limited to 14.

This card is to be used if the W1 card specifies half-wave lengths in the wave value definition and lists wave input options 3, 4, or 5. If the wave input option on the W1 card is 5, this W3 card should have exactly three values.

CARD BL Left Boundary Condition Definition, Side y = -b/2

Columns		
1-2	"BL"	
9-10	Boundary Condition	
	"CL"	Clamped
	"FR"	Free
	"SS"	Simply supported
	Blank	The degrees of freedom are specified in columns 11-70
11-15	= 1	Displacement w = 0 (constrained)
	= 2	Use columns 31-40
16-20	= 1	Displacement $\theta_y = 0$
	= 2	Use columns 41-50
21-25	= 1	Displacement v = 0
	= 2	Use columns 51-60
26-30	= 1	Displacement u = 0
	= 2	Use columns 61-70
31-40	= 0 (or blank)	Force $\hat{Q} = 0$
	= V	Spring constant k_w = V
41-50	= 0 (or blank)	Force $\hat{M} = 0$
	= V	Spring constant k_θ = V
51-60	= 0 (or blank)	Force $\hat{N} = 0$
	= V	Spring constant k_v = V
61-70	= 0 (or blank)	Force $\hat{T} = 0$
	= V	Spring constant k_u = V

In the above, V represents a nonzero value. When the boundary condition is specified as "CL", "FR", or "SS", the columns 11-70 are left blank. These preset boundary conditions give the following:

$$\text{CL:} \quad w = \theta_y = \hat{N} = u = 0$$

$$\text{FR:} \quad \hat{Q} = \hat{M} = \hat{N} = \hat{T} = 0$$

$$\text{SS:} \quad w = \hat{M} = \hat{N} = u = 0$$

This card is to be used in all data cases.

CARD BR Right Boundary Condition Definition, Side $y = +b/2$

Columns

1-2 "BR"

3-80 Same format as CARD BL

This card may be used in all data cases. If the boundary condition is the same as that specified on the BL card, it may be omitted.

CARD P1 Plate Definition Card

Columns

1-2	"P1"	
5	Plate element type	
	= 1	Flat plate
	= 2	Curved plate
9-10	Number of laminas in element (maximum is 25)	
15	Not in use	
20	Not in use	
21-30	Length of element (a) (should not be specified when half-wave lengths are input.)	
31-40	Width of element (b). For a curved plate this is the midplane chord length.	
41-50	Curved plate midplane radius.	

This card is to be used in all data cases.

CARD LT Lamina Thickness Table by Layer

The LT table contains a list of lamina thicknesses in the order of the layers—the first value is the thickness of the first layer, the second value is the thickness of the second layer, and so on.

Columns

1-2	"LT"
11-80	. . ., . . ., value, . . . / where value may be nnnn, nnn.nnn, or n.nnE±nn. The number of significant digits is limited to 14.

If the table exceeds one card, additional cards of the same format are used. A maximum of 10 LT cards is allowed. There can be only one LT table.

The values in the table are delimited by commas and the physical end of the card. The table is terminated by the character slash (/). Blanks in columns 11-80 are ignored.

A value may be repeated by use of consecutive commas.

The LT card is used with scheme 1, LT-MT-LA-LM-type input.

CARD LA Lamina Fiber Angle Table by Layer

The LA table contains a list of lamina fiber angles (degrees) in the order of the layers—the first value is the angle for the first layer, the second value is the angle for the second layer, and so on. It has the same format as the LT table and all LT rules apply. See the LT card for rules.

Columns

1-2	"LA"
11-80	. . ., . . ., value, . . . / where value may be nnnn, ±nnn.nnn, or ±n.nnnE±nn. The number of digits is limited to 14.

The LT card is used with scheme 1, MT-LT-LA-LM-type input.

CARD LM Materials Table Pointer Card

The LM card is a pointer card to the materials on MT cards.

Columns

1-2	"LM"
3-80	$(m_1, m_2, \ldots, m_i)$ or $m_1, m_2, \ldots, m_i/$

The right parenthesis or the slash terminate data. Blanks in columns 3-80 are ignored. The entries are material table numbers and are ordered by layer. For instance, if m_2 is a 4, it means that layer 2 has the material properties given in MT table 4.

Entries are separated by commas. If a number is omitted between commas, the last integer given is used for that layer. The number of commas will be one less than the number of layers specified in CARD P1. (The end of the card is an implied comma—defined at the start of this section.)

More than one LM card may be used to provide the pointers. A maximum of 10 LM cards is allowed.

The LM card is used with scheme 1, MT-LT-LA-LM-type input.

CARD MT Lamina Material Properties Table

Columns	
1-2	"MT"
9-10	Table number .
11-80	. . . , . . . , value, . . . / Four variables appear in the card. They are E_{11}, E_{22}, ν_{12}, and G_{12} for one lamina. See CARD P2 for the variable descriptions.

The same rules apply for this table as the one on CARD LT.

Each MT table contains a set of unique lamina variables.

The maximum number of material tables is 40.

The MT cards are used with scheme 1, MT-LT-LA-LM-type input, and scheme 2, MT-TT-AT-P3-type input.

CARD TT Lamina Thickness Table

The TT table contains a list of unique lamina thicknesses.

Columns

1-2	"TT"
11-80	. . . , . . . , value, . . . / where *value* may be ±nnnn, ±nnn.nnn, or ±n.nnnE±nn. The number of significant digits is limited to 14. If the table exceeds one card, additional cards of the same format are used. A maximum of 10 TT cards is allowed. There can be only one thickness table. The values in the table are delimited by commas and the physical end of card. The table is terminated by the character slash (/). Blanks in columns 11-80 are ignored.

The TT card is used with scheme 2, MT-TT-AT-P3-type input.

CARD AT Lamina Fiber Angle Table

The AT table contains a list of unique lamina fiber angles (degrees). It has the same format as the LT table and all the LT rules apply. See the LT card for rules.

Columns

1-2	"AT"
11-80	. . . , . . ., value, . . . / where *value* may be nnnn, ±nnn.nnn, or ±n.nnnE±nn. The number of significant digits is limited to 14.

The AT card is used with scheme 2, MT-TT-AT-P3-type input.

CARD P3 Lamina Pointer Card

The P3 card is used in conjunction with the TT, MT, and AT cards. These cards are used in place of the P2 cards for repetitive lamina data.

Columns

1-2	"P3"
3-80	$(\ell_1, \ell_2, \ldots, \ell_i / m_1, m_2, \ldots, m_i / n_1, n_2, \ldots, n_i)$ or $(\ell_1, \ell_2, \ldots, \ell_i / m_1, m_2, \ldots, m_i)$

The left and right parentheses are used to initiate and terminate the data. The information may be punched on more than one card. Blanks in columns 3-80 are ignored. Each entry between the left parenthesis and the first slash (/) is a pointer to the actual data in the TT card. For instance, the second value, ℓ_2, might be a "3". This means that the second layer has the thickness value in the third position of the TT table. The entries after the first slash are MT table numbers. If m_1 is a 4, it means that the first layer has the material properties given in MT table 4. The entries after the second slash are pointers to entries in the AT table. This set of entries is omitted if no AT card is used; that is, all angles are zero. If n_i is 6, it means that the i^{th} layer has the angle value in the sixth position of the angle table.

As indicated in the examples just given, the entries in each set on CARD P3 are in the order of layers and are separated with commas. If a number is omitted between commas, the last integer given is used for that layer. The number of commas for each of the three (or two) sets must be equal, and must be one less than the number of layers specified in CARD P1. (The end of the card is an implied comma–defined at start of this section.)

More than one P3 card may be used to provide all the pointers. A maximum of 10 P3 cards is allowed.

The P3 card is used with scheme 2, MT-TT-AT-P3-type input.

CARD P2 Lamina Thickness and Material Properties Card

Columns

1-2	"P2"
11-20	Thickness of lamina (t)
21-30	E–modulus for direction 1 - (E_{11})
31-40	E–modulus for direction 2 - (E_{22})
41-50	Poisson's ratio (ν_{12})
51-60	G–modulus (G_{12})
61-70	Fiber angle (ϕ_k), degrees

The subscript 1 denotes the longitudinal axis and the subscript 2 the transverse axis of the plate coordinate system.

Each P2 card has data values for one lamina. The P2 cards are ordered according to layer–the first P2 card for the first layer, the second P2 card for the second layer, and so on.

P2 cards are used with scheme 3, P2-type input.

CARD PA Stiffness Matrix A

Columns

1-2	"PA"
11-20	Value of A_{11}
21-30	Value of A_{12}
31-40	Value of A_{16}
41-50	Value of A_{22}
51-60	Value of A_{26}
61-70	Value of A_{66}

CARD PB Stiffness Matrix B

Columns

1-2	"PB"
11-70	Like the PA card except that values are for matrix B. The card is not required if matrix B is zero.

CARD PD Stiffness Matrix D

Columns

1-2	"PD"
11-70	Like the PA card except that values are for matrix D.

The PA, PB, and PD cards are used for scheme 4, PA-PB-PD-type input.

CARD END Last Card of Data Set

Columns

1-3 "END"

This card must terminate each data set. It is used to separate problem cases when they are stacked without separation by END-OF-RECORD cards.

7.0 OUTPUT

The items of output that are produced are as follows:

1. A header page.

   This presents the program name and a very brief description of it.

2. A listing of the data input cards.

3. Processed input information.

   This provides an interpretation of the input data in words so that the problem is better visualized.

4. Structural values for each layer.

5. A, B, and D matrices.

6. Buckling load search histories.

   There is a history printed for each half-wave number or half-wave length value. It includes the loads tried, the number of negative elements on the diagonal of the reduced stiffness matrix during the determinant calculation, and the value of the determinant which is expressed in terms of $A \cdot (2^B)$. The number of negative elements indicates the number of eigenvalues that are below the trial load.

7. Summary of loads and half-wave number or half-wave length values.

   This summary presents in a table the half-wave number or half-wave length values tried and the corresponding critical loads found; also the upper bounds are listed.

8. Overall summary of the results.

   This includes the minimum critical load found, a list of the loads, and the critical strains.

8.0 SAMPLE PROBLEMS

The following four sample input decks illustrate four ways to input the same physical plate (shown in figure 6). Each deck specifies a different half-wave length determining option. Loading chosen in all four decks is equal shear and transverse load with shear being the variable.

EXAMPLE DECK ONE

Both the C2 and C3 cards are omitted and default options accepted. The W1 card selects half-wave length values λ beginning with $\lambda = 10.0$ and increasing by steps of 10.0 until $\lambda = 100.0$. This option can be used to begin the definition of the general shape of the load vs λ curve as suggested in 2.4.

The P1 card specifies the general plate geometry. Five P2 cards (one for each layer) are input in the order of the layers (see figure 6) and specify the thickness; material constants E_{11}, E_{22}, ν_{12}, G_{12}; and fiber angle of the layer.

EXAMPLE DECK TWO

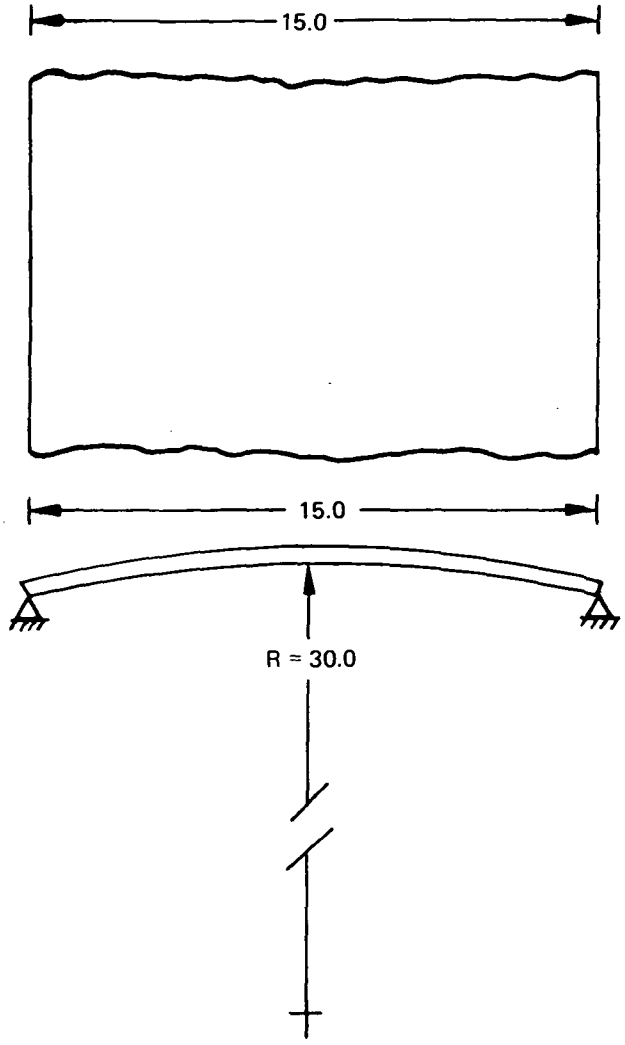
Here the C3 card has been included but since all options are blank, all default options are used. The W1 card again specifies half-wave lengths but this option required that all half-wave lengths of interest be specified on a W3 card. All layer data are supplied by table cards TT, MT, and AT and ordered by data supplied on a P3 card.

EXAMPLE DECK THREE

Both the C2 and C3 cards have been included but will get the default options as no other options are chosen. In this case the W1 option is set to search for a minimum load beginning with the three input half-wave lengths specified on the W3 card. This search procedure is discussed in section 2.4. The A, B, D matrices described in reference 1 are input on PA, PB, and PD cards. Since $B \equiv 0$ the PB card could be omitted.

EXAMPLE DECK FOUR

Both the C2 and C3 cards are omitted and default options accepted. The W1 card specifies half-wave lengths, and the half-wave length of interest is specified on the W3 card. All layer data are supplied by LT, MT, and LA cards. The applicable MT tables are specified for each layer by the LM card.



Material: boron/epoxy

Number of layers: five

Layer No.	Thickness, in.	Angle, deg
1	0.0055	+45
2	0.0055	-45
3	0.0055	+45
4	0.0055	-45
5	0.0055	+45

FIGURE 6.–SAMPLE PROBLEM

S 0 3 5 2 A / B U C L A P 2 P R O G R A M

BUCKLING LOADS FOR LONG LAMINATED PLATES

UNIFORM INPLANE LOADING -- (1) NORMAL AND (2) SHEAR

PLATE TYPES -- (1) FLAT OR (2) CURVED

ANALYSIS -- LINEAR, ELASTIC

```
P R O B L E M   T I T L E --     EXAMPLE  DECK  ONE

   DATA INPUT CARDS--

       0....*....1....*....2....*....3....*....4....*....5....*....6....*....7....*....8

        C1     EXAMPLE  DECK  ONE
        LC        4              1.0
        W1        2    2         10.0        100.0     10.0
        BL       SS
        BR       SS
        P1  2     5               10.0         15.0       30.0
        P2           0.0055          30.0E6      2.7E6   .21          .7E6   45.0
        P2           0.0055          30.0E6      2.7E6   .21          .7E6  -45.0
        P2           0.0055          30.0E6      2.7E6   .21          .7E6   45.0
        P2           0.0055          30.0E6      2.7E6   .21          .7E6  -45.0
        P2           0.0055          30.0E6      2.7E6   .21          .7E6   45.0
        END

       0....*....1....*....2....*....3....*....4....*....5....*....6....*....7....*....8

---- N O T E   1   ---- DATIN - THE C2 CARD HAS BEEN DEFAULTED

---- N O T E   1   ---- DATIN - THE C3 CARD HAS BEEN DEFAULTED

---- N O T E   1 9   ---- DATIN 1120 - LENGTH HAS NO MEANING, SINCE HALF-WAVE LENGTHS HAVE BEEN INPUT.
```

```
P R O B L E M   T I T L E --     EXAMPLE  DECK  ONE


   PROCESSED INPUT--

      CURVED PLATE
                        RADIUS          =     30.000
                        CHORD    WIDTH  =     15.000
                        EXTENDED WIDTH  =     15.161

      LOAD OPTION = 4
                        NX      =      -0.0000
                        NY/NXY  =       1.0000
                        NXY     =      VARIABLE

      WAVE OPTION = 2
                        (HALF WAVELENGTHS)
                           10.00        20.00        30.00        40.00        50.00
                           60.00        70.00        80.00        90.00        100.0

      LEFT  BOUNDARY
                        SIMPLY SUPPORTED
                        W       =  0.
                        MYY     =  0.
                        NYY     =  0.
                        U       =  0.

      RIGHT BOUNDARY
                        SIMPLY SUPPORTED
                        W       =  0.
                        MYY     =  0.
                        NYY     =  0.
                        U       =  0.

      BOUNDS
                        UPPER  = CALCULATED
                        LOWER  = -0.
```

P R O B L E M T I T L E -- EXAMPLE DECK ONE

---- STRUCTURAL VALUES FOR EACH LAYER ----

LAYER	THICKNESS	E11	E22	NU12	NU21	G	THETA
1	.00550	3.0000E+07	2.7000E+06	.21000	.01890	7.0000E+05	45.000
2	.00550	3.0000E+07	2.7000E+06	.21000	.01890	7.0000E+05	-45.000
3	.00550	3.0000E+07	2.7000E+06	.21000	.01890	7.0000E+05	45.000
4	.00550	3.0000E+07	2.7000E+06	.21000	.01890	7.0000E+05	-45.000
5	.00550	3.0000E+07	2.7000E+06	.21000	.01890	7.0000E+05	45.000

P R O B L E M T I T L E -- EXAMPLE DECK ONE

---- A - B - D MATRICES ----

A-MATRIX

252785.653	214285.653	37687.080
214285.653	252785.653	37687.080
37687.080	37687.080	217881.020

B-MATRIX

0.000	0.000	0.000
0.000	0.000	0.000
0.000	0.000	0.000

D-MATRIX

15.931	13.504	6.935
13.504	15.931	6.935
6.935	6.935	13.731

P R O B L E M T I T L E -- EXAMPLE DECK ONE

---- BUCKLING LOAD SEARCH HISTORY ----

HALF-WAVE LENGTH = 10.000

VARIABLE LOAD TRIAL	NUMBER OF NEG. ON DIAG.	BUCKLING DETERMINANT=A*(2**B) A	B
19.81906	1	-.14612	72
.00396	0	.09338	80
17.74125	0	.26878	72
18.50371	0	.07992	72
19.00731	1	-.33494	68
18.88806	0	.33132	64
18.89763	1	-.13528	64
18.89481	0	.58257	56

HALF-WAVE LENGTH = 10.000
UPPER BOUND = 39.638113
LOAD = 18.896220

The outputs of buckling load search histories for the following half-wave lengths have been deleted: 20.0, 30.0, 40.0, 50.0, 60.0, 70.0, 80.0, 90.0, 100.0.

P R O B L E M T I T L E -- EXAMPLE DECK ONE

---- SUMMARY OF LOADS CALCULATED AT VARIOUS HALF-WAVE LENGTHS (OR NUMBERS) ----

HALF-WAVE LENGTHS	UPPER BOUND	LOAD
10.00000	39.63811	18.89622
20.00000	25.35979	8.660043
30.00000	23.43768	5.569655
40.00000	22.93107	3.847947
50.00000	22.72379	3.289014
60.00000	22.61812	3.055334
70.00000	22.55671	2.930499
80.00000	22.51777	2.819897
90.00000	22.49148	2.369870
100.0000	22.47288	1.816653

P R O B L E M T I T L E -- EXAMPLE DECK ONE

---- OVERALL SUMMARY ----

THE MINIMUM LOAD FOUND WAS THE FOLLOWING ---

HALF-WAVE LENGTH = 100.00
LOAD = 1.8166527

LOAD SUMMARY INCLUDING THE MINIMUM LOAD ---

NX =-0.
NY = 1.8166527
NXY = 1.8166527

CRITICAL STRAINS SUMMARY ---

ALONG THE PLATE AXES --

EPSILON X	EPSILON Y	GAMMA XY
-2.22844E-05	2.49014E-05	7.88516E-06

IN THE FIBER DIRECTION --

LAYERS	THETA	EPSILON 11	EPSILON 22	GAMMA 12
1	45.000	5.25107E-06	-2.63409E-06	4.71858E-05
2	-45.000	-2.63409E-06	5.25107E-06	-4.71858E-05
3	45.000	5.25107E-06	-2.63409E-06	4.71858E-05
4	-45.000	-2.63409E-06	5.25107E-06	-4.71858E-05
5	45.000	5.25107E-06	-2.63409E-06	4.71858E-05

T H E E N D O F T H I S C A S E

EXAMPLE DECK TWO

```
S 0 3 5 2 A / B U C L A P 2   P R O G R A M

BUCKLING LOADS FOR LONG LAMINATED PLATES

UNIFORM INPLANE LOADING -- (1) NORMAL AND (2) SHEAR

PLATE TYPES             -- (1) FLAT  OR  (2) CURVED

ANALYSIS                --       LINEAR,    ELASTIC
```

```
---- N O T E     4 9   ---- PRERD 210 - EITHER A BL OR A BR CARD IS MISSING.  BOTH BOUNDARIES WILL BE SET
                                        TO THE ONE CONDITION SUPPLIED.
P R O B L E M   T I T L E --      EXAMPLE DECK TWO


   DATA INPUT CARDS--

       0....*....1....*....2....*....3....*....4....*....5....*....6....*....7....*....8

        C1     EXAMPLE DECK TWO
        C3
        LC        4,              1.0
        W1        2     4
        W3         10.,20.,30.,40.,50.,60.,70.,80.,90.,100./
        BL       SS
        TT           0.0055 /
        MT        1    30.0E6,2.7E6,.21,.7E6/
        AT             45.,-45./
        P1  2     5          1     10.0       15.0       30.0
        P3       (1,,,,/1,,,,/1,2,1,2,1)
        END

       0....*....1....*....2....*....3....*....4....*....5....*....6....*....7....*....8


---- N O T E    1   ---- DATIN - THE C2 CARD HAS BEEN DEFAULTED

---- N O T E    1 9   ---- DATIN 1120 - LENGTH HAS NO MEANING, SINCE HALF-WAVE LENGTHS HAVE BEEN INPUT.
```

PROBLEM TITLE -- EXAMPLE DECK TWO

PROCESSED INPUT--

CURVED PLATE

RADIUS = 30.000
CHORD WIDTH = 15.000
EXTENDED WIDTH = 15.161

LOAD OPTION = 4

NX = -0.0000
NY/NXY = 1.0000
NXY = VARIABLE

WAVE OPTION = 2

(HALF WAVELENGTHS)

10.00	20.00	30.00	40.00	50.00
60.00	70.00	80.00	90.00	100.0

LEFT BOUNDARY

SIMPLY SUPPORTED
W = 0.
MYY = 0.
NYY = 0.
U = 0.

RIGHT BOUNDARY

SIMPLY SUPPORTED
W = 0.
MYY = 0.
NYY = 0.
U = 0.

BOUNDS

UPPER = CALCULATED
LOWER = -0.

P R O B L E M T I T L E -- EXAMPLE DECK TWO

---- STRUCTURAL VALUES FOR EACH LAYER ----

LAYER	THICKNESS	E11	E22	NU12	NU21	G	THETA
1	.00550	3.0000E+07	2.7000E+06	.21000	.01890	7.0000E+05	45.000
2	.00550	3.0000E+07	2.7000E+06	.21000	.01890	7.0000E+05	-45.000
3	.00550	3.0000E+07	2.7000E+06	.21000	.01890	7.0000E+05	45.000
4	.00550	3.0000E+07	2.7000E+06	.21000	.01890	7.0000E+05	-45.000
5	.00550	3.0000E+07	2.7000E+06	.21000	.01890	7.0000E+05	45.000

P R O B L E M   T I T L E --   EXAMPLE DECK TWO

---- A - B - D MATRICES ----

A-MATRIX

252785.653	214285.653	37687.080
214285.653	252785.653	37687.080
37687.080	37687.080	217881.020

B-MATRIX

0.000	0.000	0.000
0.000	0.000	0.000
0.000	0.000	0.000

D-MATRIX

15.931	13.504	6.935
13.504	15.931	6.935
6.935	6.935	13.731

P R O B L E M T I T L E -- EXAMPLE DECK TWO

---- BUCKLING LOAD SEARCH HISTORY ----

HALF-WAVE LENGTH = 10.000

VARIABLE LOAD TRIAL	NUMBER OF NEG. ON DIAG.	BUCKLING DETERMINANT=A*(2**B) A	B
19.81906	1	-.14612	72
.00396	0	.09338	80
17.74125	0	.26878	72
18.50371	0	.07992	72
19.00731	1	-.33494	68
18.88806	0	.33132	64
18.89763	1	-.13528	64
18.89481	0	.58257	56

HALF-WAVE LENGTH = 10.000
UPPER BOUND = 39.638113
LOAD = 18.896220

The outputs of buckling load search histories for the following half-wave lengths have been deleted: 20.0, 30.0, 40.0, 50.0, 60.0, 70.0, 80.0, 90.0, 100.0.

P R O B L E M T I T L E -- EXAMPLE DECK TWO

---- SUMMARY OF LOADS CALCULATED AT VARIOUS HALF-WAVE LENGTHS (OR NUMBERS) ----

HALF-WAVE LENGTHS	UPPER BOUND	LOAD
10.00000	39.63811	18.89622
20.00000	25.35979	8.660043
30.00000	23.43768	5.569655
40.00000	22.93107	3.847947
50.00000	22.72379	3.289014
60.00000	22.61812	3.055334
70.00000	22.55671	2.930499
80.00000	22.51777	2.819897
90.00000	22.49148	2.369870
100.0000	22.47288	1.816653

P R O B L E M T I T L E -- EXAMPLE DECK TWO

---- OVERALL SUMMARY ----

THE MINIMUM LOAD FOUND WAS THE FOLLOWING ---

HALF-WAVE LENGTH = 100.00
LOAD = 1.8166527

LOAD SUMMARY INCLUDING THE MINIMUM LOAD ---

NX =-0.
NY = 1.8166527
NXY = 1.8166527

CRITICAL STRAINS SUMMARY ---

ALONG THE PLATE AXES --

EPSILON X	EPSILON Y	GAMMA XY
-2.22844E-05	2.49014E-05	7.88516E-06

IN THE FIBER DIRECTION --

LAYERS	THETA	EPSILON 11	EPSILON 22	GAMMA 12
1	45.000	5.25107E-06	-2.63409E-06	4.71858E-05
2	-45.000	-2.63409E-06	5.25107E-06	-4.71858E-05
3	45.000	5.25107E-06	-2.63409E-06	4.71858E-05
4	-45.000	-2.63409E-06	5.25107E-06	-4.71858E-05
5	45.000	5.25107E-06	-2.63409E-06	4.71858E-05

T H E E N D O F T H I S C A S E

S 0 3 5 2 A / B U C L A P 2 P R O G R A M

BUCKLING LOADS FOR LONG LAMINATED PLATES

UNIFORM INPLANE LOADING -- (1) NORMAL AND (2) SHEAR

PLATE TYPES -- (1) FLAT OR (2) CURVED

ANALYSIS -- LINEAR, ELASTIC

```
P R O B L E M   T I T L E --     EXAMPLE DECK THREE

   DATA INPUT CARDS--

      0....*....1....*....2....*....3....*....4....*....5....*....6....*....7....*....8

       C1     EXAMPLE DECK THREE
       C2
       C3
       LC        4            1.0
       W1        2    5
       W3         10.,20.,30./
       BL       SS
       BR       SS
       P1  2     5    1    1    10.0      15.0      30.0
       PA         252785.653214285.65337687.080 252785.653 37687.080217881.020
       PB
       PD         15.93076  13.50446  6.935208  15.93076  6.935208  13.7310434
       END

      0....*....1....*....2....*....3....*....4....*....5....*....6....*....7....*....8

---- N O T E   1 9   ---- DATIN 1120 - LENGTH HAS NO MEANING, SINCE HALF-WAVE LENGTHS HAVE BEEN INPUT.
```

```
P R O B L E M   T I T L E --     EXAMPLE DECK THREE


   PROCESSED INPUT--

        CURVED PLATE
                              RADIUS          =     30.000
                              CHORD     WIDTH =     15.000
                              EXTENDED  WIDTH =     15.161

        LOAD OPTION = 4
                              NX      =      -0.0000
                              NY/NXY  =       1.0000
                              NXY     =      VARIABLE

        WAVE OPTION = 2
                              (HALF WAVELENGTHS)
                                 10.00         20.00         30.00

        LEFT  BOUNDARY
                              SIMPLY SUPPORTED
                              W       =  0.
                              MYY     =  0.
                              NYY     =  0.
                              U       =  0.

        RIGHT BOUNDARY
                              SIMPLY SUPPORTED
                              W       =  0.
                              MYY     =  0.
                              NYY     =  0.
                              U       =  0.

        BOUNDS
                              UPPER   = CALCULATED
                              LOWER   = -0.
```

P R O B L E M T I T L E -- EXAMPLE DECK THREE

---- A - B - D MATRICES ----

A-MATRIX

252785.653	214285.653	37687.080
214285.653	252785.653	37687.080
37687.080	37687.080	217881.020

B-MATRIX

-0.000	-0.000	-0.000
-0.000	-0.000	-0.000
-0.000	-0.000	-0.000

D-MATRIX

15.931	13.504	6.935
13.504	15.931	6.935
6.935	6.935	13.731

P R O B L E M T I T L E -- EXAMPLE DECK THREE

---- BUCKLING LOAD SEARCH HISTORY ----

HALF-WAVE LENGTH = 30.000

VARIABLE LOAD TRIAL	NUMBER OF NEG. ON DIAG.	BUCKLING DETERMINANT=A*(2**B) A	B
11.71884	2	.07872	60
.00234	0	.68112	64
5.86059	1	-.85533	56
5.25189	0	.08863	60
5.48843	0	.31102	56
5.60504	1	-.12605	56
5.56894	0	.49628	48
5.57037	1	-.82565	48

HALF-WAVE LENGTH = 30.000
UPPER BOUND = 23.437675
LOAD = 5.5696547

The outputs of buckling load search histories for the following half-wave lengths have been deleted: 20.0, 10.0, 150.0, 750.0, 3750.0, 3790.204.

P R O B L E M T I T L E -- EXAMPLE DECK THREE

---- SUMMARY OF LOADS CALCULATED AT VARIOUS HALF-WAVE LENGTHS (OR NUMBERS) ----

HALF-WAVE LENGTHS	UPPER BOUND	LOAD
10.00000	39.63811	18.89622
20.00000	25.35978	8.660042
30.00000	23.43767	5.569655
150.0000	22.42951	.9224295
750.0000	22.39684	.6855878
3750.000	22.39554	.6840316
3790.204	22.39554	.6840307

P R O B L E M T I T L E -- EXAMPLE DECK THREE

---- OVERALL SUMMARY ----

THE MINIMUM LOAD FOUND WAS THE FOLLOWING ---

HALF-WAVE LENGTH = 3790.2
LOAD = .68403069

LOAD SUMMARY INCLUDING THE MINIMUM LOAD ---

NX =-0.
NY = .68403069
NXY = .68403069

CRITICAL STRAINS SUMMARY ---

ALONG THE PLATE AXES --

EPSILON X	EPSILON Y	GAMMA XY
-8.39083E-06	9.37621E-06	2.96903E-06

T H E E N D O F T H I S C A S E

EXAMPLE DECK FOUR

```
S 0 3 5 2 A / B U C L A P 2   P R O G R A M

      BUCKLING LOADS FOR LONG LAMINATED PLATES

UNIFORM INPLANE LOADING -- (1) NORMAL AND (2) SHEAR

PLATE TYPES             -- (1) FLAT  OR  (2) CURVED

ANALYSIS                --        LINEAR,    ELASTIC
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```
P R O B L E M   T I T L E --     EXAMPLE DECK FOUR

   DATA INPUT CARDS--

      0....*....1....*....2....*....3....*....4....*....5....*....6....*....7....*....8

       C1     EXAMPLE DECK FOUR
       LC        4              1.0
       W1        2    4
       W3          10./
       BL       SS
       BR       SS
       LT          0.0055,,,,/
       MT        1   30.0E6,2.7E6,.21,.7E6/
       LA         45.,-45.,45.,-45.,45./
       P1  2     5          1     10.0       15.0       30.0
       LM         1,,,,/
       END

      0....*....1....*....2....*....3....*....4....*....5....*....6....*....7....*....8

---- N O T E   1   ---- DATIN - THE C2 CARD HAS BEEN DEFAULTED

---- N O T E   1   ---- DATIN - THE C3 CARD HAS BEEN DEFAULTED

---- N O T E   1 9   ---- DATIN 1120 - LENGTH HAS NO MEANING, SINCE HALF-WAVE LENGTHS HAVE BEEN INPUT.
```

P R O B L E M T I T L E -- EXAMPLE DECK FOUR

PROCESSED INPUT--

CURVED PLATE

RADIUS	=	30.000
CHORD WIDTH	=	15.000
EXTENDED WIDTH	=	15.161

LOAD OPTION = 4

NX	=	-0.0000
NY/NXY	=	1.0000
NXY	=	VARIABLE

WAVE OPTION = 2

(HALF WAVELENGTHS)
10.00

LEFT BOUNDARY

SIMPLY SUPPORTED

W	=	0.
MYY	=	0.
NYY	=	0.
U	=	0.

RIGHT BOUNDARY

SIMPLY SUPPORTED

W	=	0.
MYY	=	0.
NYY	=	0.
U	=	0.

BOUNDS

UPPER	=	CALCULATED
LOWER	=	-0.

P R O B L E M T I T L E -- EXAMPLE DECK FOUR

---- STRUCTURAL VALUES FOR EACH LAYER ----

LAYER	THICKNESS	E11	E22	NU12	NU21	G	THETA
1	.00550	3.0000E+07	2.7000E+06	.21000	.01890	7.0000E+05	45.000
2	.00550	3.0000E+07	2.7000E+06	.21000	.01890	7.0000E+05	-45.000
3	.00550	3.0000E+07	2.7000E+06	.21000	.01890	7.0000E+05	45.000
4	.00550	3.0000E+07	2.7000E+06	.21000	.01890	7.0000E+05	-45.000
5	.00550	3.0000E+07	2.7000E+06	.21000	.01890	7.0000E+05	45.000

P R O B L E M T I T L E -- EXAMPLE DECK FOUR

---- A - B - D MATRICES ----

A-MATRIX

252785.653	214285.653	37687.080
214285.653	252785.653	37687.080
37687.080	37687.080	217881.020

B-MATRIX

0.000	0.000	0.000
0.000	0.000	0.000
0.000	0.000	0.000

D-MATRIX

15.931	13.504	6.935
13.504	15.931	6.935
6.935	6.935	13.731

P R O B L E M T I T L E -- EXAMPLE DECK FOUR

---- BUCKLING LOAD SEARCH HISTORY ----

HALF-WAVE LENGTH = 10.000

VARIABLE LOAD TRIAL	NUMBER OF NEG. ON DIAG.	BUCKLING DETERMINANT=A*(2**B) A	B
19.81906	1	-.14612	72
.00396	0	.09338	80
17.74125	0	.26878	72
18.50371	0	.07992	72
19.00731	1	-.33494	68
18.88806	0	.33132	64
18.89763	1	-.13528	64
18.89481	0	.58257	56

HALF-WAVE LENGTH = 10.000
UPPER BOUND = 39.638113
LOAD = 18.896220

P R O B L E M T I T L E -- EXAMPLE DECK FOUR

---- SUMMARY OF LOADS CALCULATED AT VARIOUS HALF-WAVE LENGTHS (OR NUMBERS) ----

HALF-WAVE LENGTHS	UPPER BOUND	LOAD
10.00000	39.63811	18.89622

P R O B L E M T I T L E -- EXAMPLE DECK FOUR

---- OVERALL SUMMARY ----

THE MINIMUM LOAD FOUND WAS THE FOLLOWING ---

HALF-WAVE LENGTH = 10.000
LOAD = 18.896220

LOAD SUMMARY INCLUDING THE MINIMUM LOAD ---

NX =-0.
NY = 18.896220
NXY = 18.896220

CRITICAL STRAINS SUMMARY ---

ALONG THE PLATE AXES --

EPSILON X	EPSILON Y	GAMMA XY
-2.31795E-04	2.59016E-04	8.20188E-05

IN THE FIBER DIRECTION --

LAYERS	THETA	EPSILON 11	EPSILON 22	GAMMA 12
1	45.000	5.46199E-05	-2.73989E-05	4.90811E-04
2	-45.000	-2.73989E-05	5.46199E-05	-4.90811E-04
3	45.000	5.46199E-05	-2.73989E-05	4.90811E-04
4	-45.000	-2.73989E-05	5.46199E-05	-4.90811E-04
5	45.000	5.46199E-05	-2.73989E-05	4.90811E-04

T H E E N D O F T H I S C A S E

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2. Halstead, David W.; Tripp, L. L.; Tamekuni, M.; and Baker, L. L.: BUCLAP2—A Computer Program for Instability Analysis of Laminated Long Plates Subjected to Combined Inplane Loads—Program Description Document. NASA CR-132299, 1973.